

CLMPTO

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[1. A programmable input/output device for coupling a programmable logic device (PLD) to external circuitry, the input/output device comprising:

an input/output pad;

an output buffer adapted to receive output signals from the PLD, the output buffer modifying the output signals and being coupled to the input/output pad;

an input buffer adapted to receive input signals from the input/output pad and from the output buffer, the input buffer modifying the input signals and being coupled to the PLD to provide the PLD with the modified input signals; and

a plurality of logic standards; and

a plurality of programmable logic elements that select a logic standard from said plurality of logic standards with which the output buffer and the input buffer respectively modify the output and input signals.

2. The programmable input/output device of claim 1,  
wherein the plurality of programmable logic elements comprises:  
    a first programmable logic element coupled to the  
output buffer and the input buffer; and  
    a second programmable logic element coupled to  
the output buffer.

3. The programmable input/output device of claim 2,  
wherein the plurality of programmable logic elements are SRAM  
elements.

4. The programmable input/output device of claim 2,  
wherein the plurality of programmable logic elements are EPROM  
elements.

5. The programmable input/output device of claim 2,  
wherein the plurality of programmable logic elements are EEPROM  
elements.

6. The programmable input/output device of claim 2,  
wherein the plurality of programmable logic elements are  
antifuse elements.

7. The programmable input/output device of claim 2,  
wherein the plurality of programmable logic elements are

elements from the group of SRAM, EPROM, EEPROM, and antifuse elements.

8. The programmable input/output device of claim 1, wherein the input/output device provides signal modification in accordance with TTL standards.

9. The programmable input/output device of claim 1, wherein the input/output device provides signal modification in accordance with CMOS logic standards.

10. The programmable input/output device of claim 1, wherein the input/output device provides signal modification in accordance with open drain logic standards.

11. The programmable input/output device of claim 1, wherein the input/output device provides signal modification in accordance with GTL standards.

12. The programmable input/output device of claim 1, wherein the input/output device provides signal modification in accordance with HSTL standards.

13. The programmable input/output device of claim 12, wherein the HSTL standard is terminated.

14. The programmable input/output device of claim 12,  
wherein the HSTL standard is non-terminated.

15. The programmable input/output device of claim 1,  
wherein the input buffer comprises:

a differential amplifier circuit being adapted to  
receive the input signals;

control circuitry that controls the modification  
of the input signals in accordance with the standard selected by  
the plurality of programmable logic elements; and

inversion circuitry that provides the modified  
input signals to the PLD.

16. The programmable input/output device of claim 15,  
wherein the differential amplifier circuit and the control  
circuit operate in conjunction with each other to provide the  
modifications of the input signals in accordance with a  
plurality of logic standards.

17. The programmable input/output device of claim 15,  
wherein the differential amplifier circuit and the control  
circuit operate independent of each other such that the  
modifications of the input signals are performed by the control  
circuitry in accordance with a first logic standard and by the

differential amplifier circuit in accordance with a second logic standard, the first and second logic standards being selected by the plurality of programmable logic elements.

18. The programmable input/output device of claim 17, wherein the control circuitry is optimized for speed to provide modification in accordance with the first logic standard at increased speed.

19. The programmable input/output device of claim 17, wherein the differential amplifier circuit is optimized for speed to provide modification in accordance with the second logic standard at increased speed.

20. A programmable input/output device for coupling a programmable logic device (PLD) to external circuitry, the input/output device comprising:

means for coupling the input/output device to the external circuitry;

means for receiving output signals from the PLD and for modifying the output signals in accordance with a selected logic standard, the means for receiving providing the modified output signals to the means for coupling;

means for modifying input signals received from the means for receiving and the means for coupling in accordance

with the selected logic standard, the means for modifying providing the modified input signals to the PLD; and means for selecting the selected logic standard from a plurality of logic standards.

21. The programmable input/output device of claim 20, wherein the means for receiving comprises:

circuitry for modifying the output signals to an appropriate high voltage level in accordance with the selected logic standard if the output signals are logic high signals; and circuitry for modifying the output signals to an appropriate low voltage level in accordance with the selected logic standard if the output signals are logic low signals.

22. The programmable input/output device of claim 21, wherein the selected logic standard is TTL, the appropriate high signal is about 2.4 volts, and the appropriate low signal is about 0.4 volts.

23. The programmable input/output device of claim 21, wherein the selected logic standard is GTL, the appropriate high signal is about 1.2 volts, and the appropriate low signal is about 0.8 volts.

24. The programmable input/output device of claim 21, wherein the selected logic standard is CMOS, the appropriate high signal is about 3.5 volts, and the appropriate low signal is about 0 volts.

25. The programmable input/output device of claim 21, wherein the selected logic standard is open drain, the appropriate high signal is determined by external circuitry, and the appropriate low signal is less than about 0.4 volts.

26. The programmable input/output device of claim 21, wherein the selected logic standard is terminated HSTL, the appropriate high signal is determined by external circuitry, and the appropriate low signal is about equal to the appropriate high signal minus 0.1 volts.

27. The programmable input/output device of claim 21, wherein the selected logic standard is non-terminated HSTL, the appropriate high signal is about equal to a predetermined reference voltage plus 0.1 volts, and the appropriate low signal is about equal to the predetermined reference voltage minus 0.1 volts.

28. The programmable input/output device of claim 20, wherein the means for modifying comprises:

a first conversion circuit for converting the input signals in accordance with a first logic standard; and a second conversion circuit for converting the input signals in accordance with a second logic standard.

29. The programmable input/output device of claim 28, wherein the first and second conversion circuits are merged into a single conversion circuit..

30. The programmable input/output device of claim 28, wherein the first and second conversion circuits are substantially independent of each other such that they may be independently optimized for operational speed improvements.

31. A method for providing a programmable logic device (PLD) with the capability of being selectively coupled to external circuitry which operates in accordance with a selected one of a plurality of logic standards, the methods comprising the steps of:

programmably selecting the selected one of a plurality of logic standards;

modifying output signals from the PLD in accordance with the selected logic standard such that high PLD signals correspond to high signals of the selected standard and

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low PLD signals correspond to low signal of the selected standard;

receiving input signals from an external interface; and

modifying the input signals in accordance with the selected logic standard such that high input signals are converted to high PLD signals and low input signals are converted to low PLD signals.

32. The method of claim 31, wherein the step of programmably selecting the selected one of a plurality of logic standards selects a logic standard from the group including: TTL, CMOS logic, open drain logic, GTL, terminated HSTL, and non-terminated HSTL.

33. The method of claim 31, wherein the step of programmably selecting comprises the step of applying a plurality of Select Bits to a plurality of programmable elements.

34. The method of claim 33, wherein the programmable elements are from the group including: SRAM, EPROM, EEPROM, and anti-fuse elements.]

35. A programmable input/output device for coupling a programmable logic device (PLD) to external circuitry, the input/output device comprising:

an input/output pad;

an output buffer adapted to receive output signals from the PLD, the output buffer modifying the output signals and being coupled to the input/output pad;

an input buffer adapted to receive a reference signal and input signals from the input/output pad and from the output buffer, the input buffer comparing the received input signals to the reference signal to produce a differential signal and coupling the differential signal to the PLD to provide the PLD with modified input signals; and

a plurality of programmable elements that select the standard with which the output buffer and the input buffer respectively modify the output and input signals.

36. The programmable input/output device of claim 35, wherein the plurality of programmable elements further comprise:

a first programmable element coupled to the output buffer and the input buffer; and

a second programmable element coupled to the output buffer.

37. The programmable input/output device of claim 36,  
wherein the plurality of programmable elements are elements  
selected from the group consisting of SRAM, EPROM, EEPROM, fuse  
and antifuse elements.

38. The programmable input/output device of claim 35,  
wherein the input/output device provides signal modification in  
accordance with logic standards selected from the group  
consisting of TTL, CMOS, GTL, and HSTL.

39. The programmable input/output device of claim 35,  
wherein the input buffer comprises:

a differential amplifier circuit being adapted to  
receive the input signals;

control circuitry that controls the modification  
of the input signals in accordance with the standard selected by  
the plurality of programmable elements; and

inversion circuitry that provides the modified  
input signals to the PLD.

40. The programmable input/output device of claim 39,  
wherein the differential amplifier circuit and the control  
circuit operate in conjunction with each other to provide the  
modifications of the input signals in accordance with a  
plurality of logic standards.

41. The programmable input/output device of claim 39,  
wherein the differential amplifier circuit and the input buffer  
operate independent of each other such that the modifications of  
the input signals are performed by the input buffer in  
accordance with a first logic standard and by the differential  
amplifier circuit in accordance with a second logic standard,  
the first and second logic standards being selected by the  
plurality of programmable elements.

42. The programmable input/output device of claim 41,  
wherein the input buffer is optimized for speed to provide  
modification in accordance with the first logic standard at  
increased speed.

43. The programmable input/output device of claim 41,  
wherein the differential amplifier circuit is optimized for  
speed to provide modification in accordance with the second  
logic standard at increased speed.

44. A programmable input/output device for coupling a  
programmable logic device (PLD) to external circuitry, the  
input/output device comprising:  
means for coupling the input/output device to the  
external circuitry;

means for receiving output signals from the PLD  
and for modifying the output signals in accordance with a  
selected logic standard, the means for receiving providing the  
modified output signals to the means for coupling;

means for modifying input signals received from  
the means for receiving and the means for coupling in accordance  
with the selected logic standard, the means for modifying  
including a means for comparing the received input signals to a  
reference signal to produce a differential signal and for  
providing the modified input signals to the PLD; and

means for selecting the selected logic standard  
from a plurality of logic standards.

45. The programmable input/output device of claim 44,  
wherein the means for receiving comprises:

circuitry for modifying the output signals to an  
appropriate high voltage level in accordance with the selected  
logic standard if the output signals are logic high signals; and

circuitry for modifying the output signals to an  
appropriate low voltage level in accordance with the selected  
logic standard if the output signals are logic low signals.

46. The programmable input/output device of claim 44,  
wherein the means for modifying comprises:

a first conversion circuit for converting the input signals in accordance with a first logic standard; and a second conversion circuit for converting the input signals in accordance with a second logic standard.

47. The programmable input/output device of claim 46, wherein the first and second conversion circuits are merged into a single conversion circuit.

48. The programmable input/output device of claim 46, wherein the first and second conversion circuits are substantially independent of each other such that they may be independently optimized for operational speed improvements.

49. A method for providing a programmable logic device (PLD) with the capability of being selectively coupled to external circuitry that operates in accordance with a selected one of a plurality of logic standards, the method comprising:

programmably selecting the selected one of a plurality of logic standards;

modifying output signals from the PLD in accordance with the selected logic standard such that high PLD signals correspond to high signals of the selected standard and low PLD signals correspond to low signal of the selected standard;

receiving input signals from an external interface;

comparing the received input signals to a reference signal to produce a differential signal in accordance with the selected logic standard such that high input signals are converted to high PLD signals and low input signals are converted to low PLD signals.

50. The method of claim 49, wherein the programmably selecting further comprises selecting a logic standard selected from the group consisting of TTL, CMOS, open drain logic, GTL, terminated HSTL, and non-terminated HSTL.

51. The method of claim 49, wherein the programmably selecting further comprises applying a plurality of Select Bits to a plurality of programmable elements.

52. A programmable input/output device capable of operating at multiple logic standards comprising:

an input/output terminal;  
a plurality of programmable elements; and  
an input buffer having circuitry controlled by at least one of the plurality of programmable elements to select between a first logic standard and a second logic standard

wherein the second logic standard is a differential logic standard.

53. The programmable input/output device of claim 52 wherein the differential logic standard is a standard selected from the group consisting of HSTL and GTL.

54. The programmable input/output device of claim 52 wherein the first logic standard is a standard selected from the group consisting of TTL or CMOS.

55. The programmable input/output device of claim 52 wherein the programmable elements are elements selected from the group consisting of SRAM, EPROM, EEPROM, and antifuse elements.

56. The programmable input/output device of claim 52 wherein the input buffer further comprises a differential amplifier circuit that is used for generating the differential logic standard.

57. The programmable input/output device of claim 52 wherein at least one programmable element is coupled to the input buffer.

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58. The programmable input/output device of claim 52  
further comprising an output buffer having circuitry controlled  
by at least one of the plurality of programmable elements to  
select between the first logic standard and the second logic  
standard.

59. The programmable input/output device of claim 58  
wherein the second logic standard is a differential logic  
standard.

60. The programmable input/output device of claim 58  
wherein at least one programmable element is coupled to the  
input buffer.

61. The programmable input/output device of claim 60  
wherein the input buffer and the output buffer are controlled by  
the same programmable element.

62. A programmable input/output buffer capable of  
operating at multiple logic standards comprising:  
an input/output terminal;  
a plurality of programmable elements; and  
an output buffer having circuitry controlled by  
at least one of the plurality of programmable elements to select  
between one logic standard and a differential logic standard.

63. The programmable input/output device of claim 62  
wherein the differential logic standard is a standard selected  
from the group consisting of HSTL and GTL.

64. The programmable input/output device of claim 62  
wherein the first logic standard is a standard selected from the  
group consisting of TTL and CMOS.

65. The programmable input/output device of claim 62  
wherein the programmable elements are elements selected from the  
group consisting of SRAM, EPROM, EEPROM, and antifuse elements.

66. The programmable input/output device of claim 62  
wherein at least one programmable element is coupled to the  
output buffer.

67. The programmable input/output device of claim 62  
further comprising an input buffer having circuitry controlled  
by at least one of the plurality of programmable elements to  
select between the first logic standard and the second logic  
standard.

68. The programmable input/output device of claim 67 wherein the second logic standard is a differential logic standard.

69. The programmable input/output device of claim 67 wherein at least one programmable element is coupled to the output buffer.

70. The programmable input/output device of claim 69 wherein the input buffer and the output buffer are controlled by the same programmable element.

71. A programmable input/output device comprising:  
an input/output terminal;  
an input buffer and an output buffer coupled to  
the input/output terminal, each of which includes means for  
modifying signals applied to the input/output terminal to a  
selected one of multiple logic standards wherein at least one of  
the multiple logic standards is a differential logic standard;  
and  
a plurality of programmable elements for  
selecting the logic standard at which the input and output  
buffers operate.

72. The programmable input/output device of claim 71 wherein the input buffer and the output buffer further comprise means for modifying signals applied to the input/output terminal to a logic standard selected from the group consisting of TTL, CMOS, GTL and HSTL.

73. The input/output device of claim 71, wherein the input buffer and the output buffer share at least one programmable element.

CLAIMS 74-75 CANCELLED